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Potential RSM Projects; West Maui Region, Maui, Hawaii

by Thomas D. Smith

BACKGROUND: The Hawaii West Maui Region (Figure 1) was the focus of Hawaii Regional Sediment Management (RSM) investigations in fiscal year 2014 (Podoski et al., in preparation). The West Maui Region extends from Hanakaoo in the south through Honolua Bay in the north (Figure 2). The conceptual regional sediment budget developed for West Maui indicates that the shoreline has been relatively stable over the past 17 years (1997 through 2014). Portions of sandy shoreline within the region, however, have been lost altogether. Critically eroding beaches in the West Maui Region have been identified by the County of Maui Planning Department and various other stakeholders. This Coastal and Hydraulics Engineering Technical Note (CHETN) identifies potential RSM projects (PRSMP) that could be implemented in the region to beneficially use sediment and enhance the environment and reviews application of the Coastal Modeling System (CMS) (Demirbilek and Rosati 2011) and the Particle Tracking Model (PTM) (Demirbilek et al. 2005a,b,c; MacDonald et al. 2006; Lackey and MacDonald 2007) numerical models to better understand the sediment transport processes in the region. While the U.S. Army Corps of Engineers (USACE) RSM program is not authorized to provide federal funds for construction, the purpose of the program is to collaborate across the USACE and, with stakeholders and partners, to identify strategies to integrate RSM opportunities into existing or new projects which lead to construction. The goal of this CHETN is to identify conceptual alternatives that could be refined and implemented through acquisition of appropriate Federal authorizations; by other Federal, state, and/or county agencies; by partnerships; or by the private sector.

POTENTIAL REGIONAL SEDIMENT MANAGEMENT PROJECTS (PRSMP) WORKSHOP: A workshop was held 17 August 2014 in Kihei, Maui, where stakeholders discussed PRSMPs that might be implemented in the West Maui Region. Participants of the workshop included USACE; U.S. Department of Agriculture, Natural Resource Conservation Service; Hawaii Department of Land and Natural Resources, Division of Aquatic Resources; Hawaii Department of Transportation; Maui County; University of Hawaii, Sea Grant; Sea Engineering, Inc.; Maui Nui Marine Resource Council; Coral Reef Alliance; The Nature Conservancy; Henningson, Durham, and Richardson, Inc.; Kampgrounds Of America; Royal Kahana Resort; Chris Hart and Partners; and Ailana Surveying. Three workshop breakout sessions were convened. One session was devoted to engineering considerations associated with implementation of PRSMPs in the region. A second session was devoted to environmental considerations. The third breakout session consisted of identifying PRSMPs in the region. The following are conclusions and recommendations of the PRSMP three workshop breakout sessions: (1) Engineering Considerations, (2) Environmental Considerations, and (3) Potential RSM Projects.

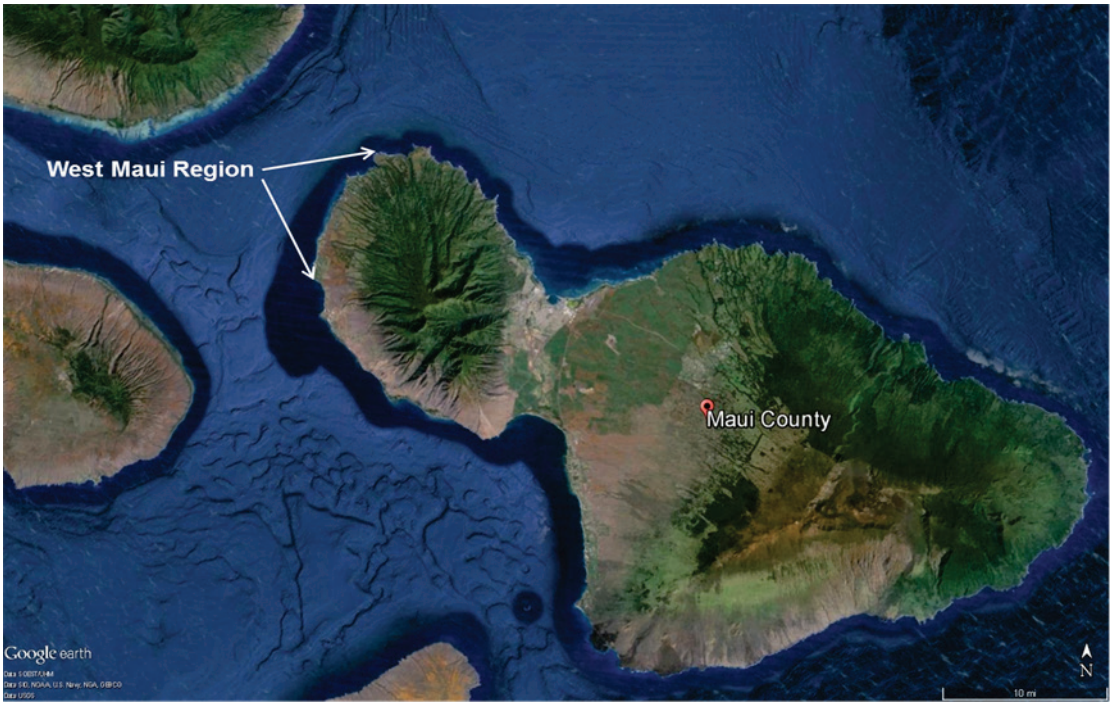

Figure 1. West Maui RSM Region, Maui County, HI.

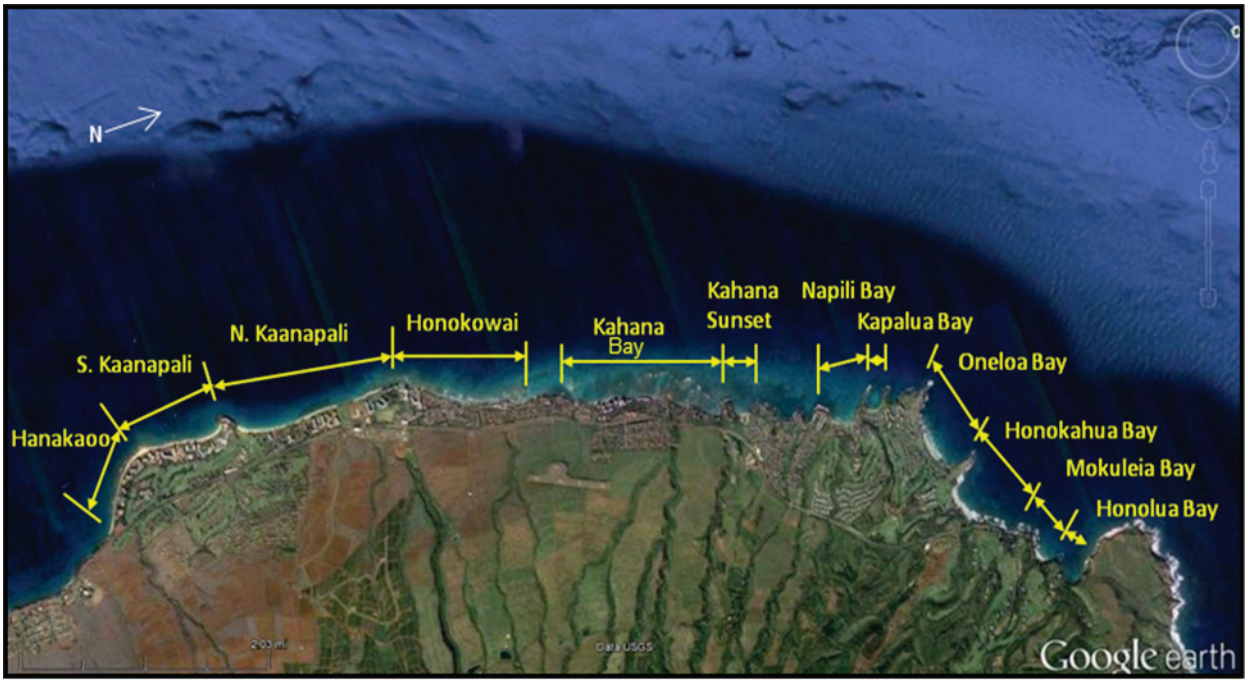

Figure 2. Littoral cells that comprise the West Maui RSM Region, Maui County, HI.

Engineering Considerations.

1. Any RSM activities should optimize beneficial use of dredged material (both Federal and non-Federal operations). A factor to be considered is there is no pump-out capability

aboard the USACE hopper dredge *Essayons*, which is used for dredging operations in the USACE, Honolulu District.

2. Most sources of offshore sand are in small sand fields located in relatively deep water. The volume of suitable offshore sand available should be quantified, along with the cost associated with dredging and placing it on various beaches within the region.
3. The nominal interval for beach renourishment in the region should be determined.
4. The impacts of beach nourishment in the region (both economic and environmental) should be identified.
5. Lessons learned from shore protection efforts in the West Maui Region should be documented.
6. The Sugar Cove beach nourishment project (previous homeowner-sponsored project) should be reviewed. Approximate cost is $60,000 per year. Fill material is fine sand.
7. The need for terminal structures for beach nourishment/fill on an open coast should be investigated.
8. The potential for hotels to share in the cost of beach nourishment projects should be determined. Tourists could contribute through assessment of a bed tax.
9. The engineering benefits of combining different shore protection alternatives should be quantified. An example would be construction of a revetment and nourishment of the beach. This is a hybrid solution that has been used with some success in past projects in the region.
10. Pushing sand to recreate a berm is another option that has minimal cost and minimal equipment requirements and can provide short-term protection.
11. Temporary placement of sand bags in the winter season should be considered. This concept is acceptable to the resource and permitting agencies, provides protection in the winter, and can be removed at the end of the season.
12. West Maui region has many areas with erosion issues at the end of cells due to seasonality of shoreline accretion/erosion (short-term). In many areas, there is also long-term erosion that is occurring in addition to seasonal erosion. Both short- and long-term erosion should be investigated in a site-specific manner through quantification of regional coastal processes.
13. Best management practices (BMPs) for the use of upland sediment sources are needed so that proper physical and chemical characteristics are met for placement on the beach.
14. A big picture consideration is whether natural or engineered beaches are preferable in these areas. The answer varies by region (e.g., West Maui vs. Waikiki).
15. The Napili Bay/Kapalua beach nourishment plan can serve as a model for beach nourishment in the West Maui Region.
16. Beach nourishment project should be designed to maximize sand retention time through use of *headland* control features. Regional beach project implementation should be promoted (e.g., Pohailani Condos to Pohaku Beach Park beach nourishment with headland control structures).
17. The possibility of moving roads inland to eliminate the need for hardened coastal structures to stabilize highways should be investigated.

Environmental Considerations.

1. The consequences of introducing sediment into the littoral environment should be determined. There is concern that a portion of sand placed on the beaches within the

region will be transported offshore onto the reef. Impacts of the transport of sand onto the reef include, but are not limited to, covering (smothering) of coral and filling voids in the reef that provide habitat for various marine organisms.

2. The knowledge gap concerning the impacts of beach fill projects on reef systems should be eliminated. To date, there has been limited study of the impacts of sand on reef environments. Anecdotal indications that sand negatively impacts reef systems need to be substantiated by rigorous scientific investigation. Until that time, resource agencies along with beach nourishment proponents should not rely on broad, unsubstantiated claims to promote their points of view.
3. The physical and chemical characteristic of calcium carbonate versus terrestrial sediment should be investigated. It may be possible to introduce varying percentages of these types of sediment into the littoral system with favorable results.
4. The impacts of fine grain sand with particular focus on the dynamics of sediment that can be resuspended into the water column by waves and currents should be studied. The residence time of these sediments on reefs in the West Maui Region should be determined.
5. More water quality stations within the region should be established and ensured that they accurately measure constituents of interest. There are a limited number of water quality sensors in the West Maui Region. A suitable water quality network should be developed, and funding should be sought for installation, operation, and maintenance of the network.
6. At least one laboratory should be established on Maui that can process water quality samples. Currently, water quality samples from Maui are sent to off-island laboratories. Test results are often not provided soon enough to enable avoidance of a potential threat.
7. It should be confirmed that beach fill material is compatible with the native beach sand. Overly fine-grained sand as well as overly coarse sand could potentially be detrimental to the littoral system.
8. The potential impacts of utilizing offshore sand resources for beach nourishment should be investigated. Dredging operations can generate sediment plumes, and exposure of clay layers or other unwanted material can release fine-grained material. Sand sources in deeper water may possibly be dredged with fewer impacts to the reef system. Even so, such impacts may be either short term or long term.
9. Potential inland RSM projects may be feasible. Sediment retention basins inland from the coast should be investigated. Stream flows may possibly be redirected away from the coast. The construction of erosion control structures should be considered to reduce stream sedimentation. Feral animal control should be implemented to reduce the amount of barren soil. Barren areas should be revegetated. Postfire restoration response to stabilize exposed ground should be performed.
10. Ecological assessment of beach fills to investigate their sustainability should be conducted, and long-term impacts should be identified.

Potential RSM Projects.

1. The Hawaii Department of Health, Environmental Management Division, Clean Water Branch (CWB), implements the intent of the Clean Water Act (CWA) under the stewardship of the U.S. Environmental Protection Agency (EPA). The CWB should advocate for increased EPA involvement in the enforcement of the CWA. Increased

involvement and oversight from the EPA would ensure that CWA standards are carried out on a consistent basis throughout the country.

2. RSM can address brown water issues caused by agriculture and construction site runoff (an inland issue that must be addressed through enforcement and permitting processes). Runoff from construction sites is often sediment laden and ultimately results in increased turbidity in nearshore coastal waters. Improved sediment BMPs at construction sites can be employed to reduce point-source runoff.
3. Alternate solutions must be available when it becomes apparent that existing BMPs do not apply to a specific area. RSM could help with site design and enhanced BMPs for these areas. Examples include Honokahua Bay, Mahana Ridge (originally part of Kapalua Mauka permits in 2007 that promised no negative downstream effects), and Honolua Bay.
4. Outreach and guidance should be offered to stakeholders in the West Maui Region regarding RSM concepts, modeling, research, and coordination. This will aid in better understanding the sediment/reef relationships through RSM principles. Knowledge gaps, current tools, and anticipated future needs should be identified to aid in planning. A series of workshops to provide RSM guidance to the West Maui Region stakeholders should be conducted.
5. Models applied for RSM in coastal Hawaii inherently need to be different from models applied for RSM on the mainland. Models applied in coastal Hawaii need to incorporate the effects of steep offshore slopes, wide shallow reefs, incident wave climate, etc. Hawaii needs more specific coastal data to allow for variations in beach and storm characteristics when modeling projects for RSM and sediment transport. Models applied on the mainland may not accurately predict island coastal processes.
6. Detailed offshore sand investigations in support of beach nourishment should be conducted. Viable sand resources through reconnaissance sampling, geophysics, etc., should be ascertained. When viable sand resources are identified, workshops with communities to discuss beach nourishment logistics should be conducted. Primary candidate areas include Napili Bay and Kahana Bay.
7. The Kahana Bay Regional Beach Nourishment Project could easily be incorporated into a potential offshore sand investigation project. The nourishment project could then focus on retention structures, monitoring, and research to develop an alternative to shore hardening.

Based on the findings and consensus of opinion of the participants at the 17 August 2014 RSM workshop held in Kihei, Maui, the County of Maui identified Kahana Bay (Figure 2) as its first PRSMP priority.

KAHANA BAY: COUNTY OF MAUI FIRST PRIORITY PRSMP: The shoreline within this reach of the West Maui Region is chronically eroding and various types of *hard* shore protection alternatives have been recommended to reduce future economic and environmental impacts. The following accounts are provided as background to the shoreline erosion issues experienced in the area.

1. The shoreline fronting the Hololani Resort Condominiums has experienced chronic erosion at an annual average rate of approximately 0.8 feet (ft) per year. Since 1959, the shoreline has eroded approximately 40 ft and the Hololani Resort has lost approximately

5,000 square feet (ft^2) of property. The problem is at least partly due to seasonal erosion. North swells in the winter push the sand to the southern end of the littoral cell, but south swells in the summer bring some of that sand back. Swells from the north and northeast are especially an issue because they enter the channel and can transport large volumes of sand quickly into this area. However, historical data suggests that the entire cell is losing sand.

2. The Hololani Resort is not the only property with erosion problems in this area. There are six other hotels in this littoral cell, including the Pohailani Condominiums to the north, Royal Kahana Resort immediately south, and the Valley Isle, Sands of Kahana, and Kahana Beach Resort farther south. The Pohailani Condominiums have a seawall that was recently reconstructed in 2012–2013. The Royal Kahana Resort shoreline is also eroding, and the owners have placed erosion mats along part of the coastline as a temporary measure. Other hotels have placed sandbags to help protect their properties. Primarily the properties to the north are affected, but the entire littoral cell has an erosion problem.
3. The Hololani Resort funded design of shoreline protection for their property. The current design includes a seawall/rubblemound revetment structure along approximately 372 ft of shoreline. The crest elevation is 6 ft for the revetment and 12 ft for the seawall. On the south end, erosion mats would be placed along the shoreline that adjoins the Royal Kahana Resort to try to reduce impacts of end effects on the neighboring property. This was the recommended alternative because a seawall alone would reflect too much wave energy and affect coastal processes. The seawall/revetment combination reduces the footprint of the revetment. Beach nourishment alone was not recommended because the sand would most likely be transported away and not provide sufficient protection to the Hololani Resort. It was believed by some participants that groins would take too long to permit and that the Hololani Resort needs protection soon.
4. The draft environmental assessment for the Hololani Resort shoreline protection project was presented to the County of Maui Planning Commission in September 2012. One concern that was voiced at this meeting was the effect it would have on the neighboring properties. This structure could affect other properties, which would experience the same erosion problem as the Hololani Resort. It was also suggested that the Pohailani Condominium seawall exacerbated the problem at the Hololani Resort and potentially affected longshore transport in the entire cell. Several citizens called for a regional solution such as beach nourishment. Other concerns that were expressed included the revetment being too steep, dislike of shoreline hardening in general, and the visual impact. Based on these concerns, the commission recommended looking further into other alternatives including groins, an offshore breakwater, and beach nourishment.

KAHANA BAY PRSMP NUMERICAL MODELING: At the request of the Maui County Planning Division, the West Maui Region RSM coastal numerical modeling effort (Podoski et al., in preparation) was leveraged to take a closer look at the sediment transport processes within the Kahana Bay littoral cell. Maui County personnel are interested in the potential of providing shore protection to upland property and infrastructure through *soft* alternatives such as beach nourishment. Previously modeled results of waves and current forces were utilized to drive a sediment transport visualization model under differing ocean conditions. The visualizations have the potential to enable better understanding of the sediment pathways and residence times for beach nourishment within the Kahana Bay littoral cell.

Coastal Modeling System (CMS). The USACE Engineer Research and Development Center (ERDC) CMS (Demirbilek and Rosati 2011) numerical models CMS-Wave (Lin et al. 2008, 2011) and CMS-Flow (Sanchez et al. 2011) were implemented to simulate wave transformation and water circulation within the West Maui Region. Prevailing (tradewind) and predominant (northwest) winds along with northwest and south wave conditions were simulated in steering mode to capture the interdependence of waves and currents.

The regional processes influencing the West Maui Region shoreline that were considered in setting up the numerical model were exceedingly complex, and include the following:

1. A multidirectional wave climate with waves arriving from north, south, and occasionally west.
2. Wave sheltering from the islands of Lanai, Molokai, and Kahoʻolawe.
3. A propagating tide from south to north through ʻAuʻau and Pailolo channels.
4. Orographic intensification of northeast tradewinds (up to 50%) in the channels between the islands of Maui, Molokai and Lanai.
5. Large internal tides in Hawaii.
6. Complex nearshore bathymetry including coral reefs.

To better understand coastal dynamics in coral reef habitats, the U.S. Geological Survey obtained wave and current data at four locations along the west coast of Maui. Data included hourly observations of waves, currents, temperature, salinity, and turbidity off the West Maui coast for approximately 4 months between June and October 2003. All measurements were on the inner shelf in water depths of approximately 30 to 40 ft. These wave and current data were used to calibrate and validate the CMS numerical models at Kahana Bay.

The long-term time series simulations were completed for two selected time periods. The first time period was the entire year of 2003, representing an extreme storm year. The second time period was the 15-month period from September 2009 to December 2010, representing a typical year including a full winter wave season.

Particle Tracking Model (PTM). The USACE ERDC Particle Tracking Model (PTM) (Demirbilek et al. 2005a,b,c; MacDonald et al. 2006; Lackey and MacDonald 2007) is a Lagrangian PTM designed to allow the user to simulate suspended sediment transport processes. It provides powerful visualizations of potential pathways, utilizing results from both CMS-Wave and CMS-Flow. The PTM is designed to address the following processes and project needs:

1. Sediment mobility.
2. Fate of mobilized sediment.
3. Source or origin location of material in areas experiencing sedimentation.
4. Effects of anthropogenic activity on sediment pathways.
5. Fate of material released during a dredging and placement operation.
6. Stability and fate of in-place sediment, including dredged-material mounds, sediment caps, and contaminated sediment deposits.

The PTM was utilized to visualize dominant sediment pathways offshore of Kahana Bay. Results from two events in the 2003 CMS time series were used in the simulations. The time periods

identified for beach nourishment within the Kahana Bay littoral cell were (1) 25 August–2 September 2003 (south swell) and (2) 18–28 November 2003 (northwest swell). PTM runs simulated approximately 30,000 cubic yards (yd^3) of beach quality sand being placed along a 0.63-mile stretch of shoreline between Kahana Stream at the north and *S-turns* Beach Park to the south (Figure 3). Simulations did not include any sand retention structures (such as groins or breakwaters).

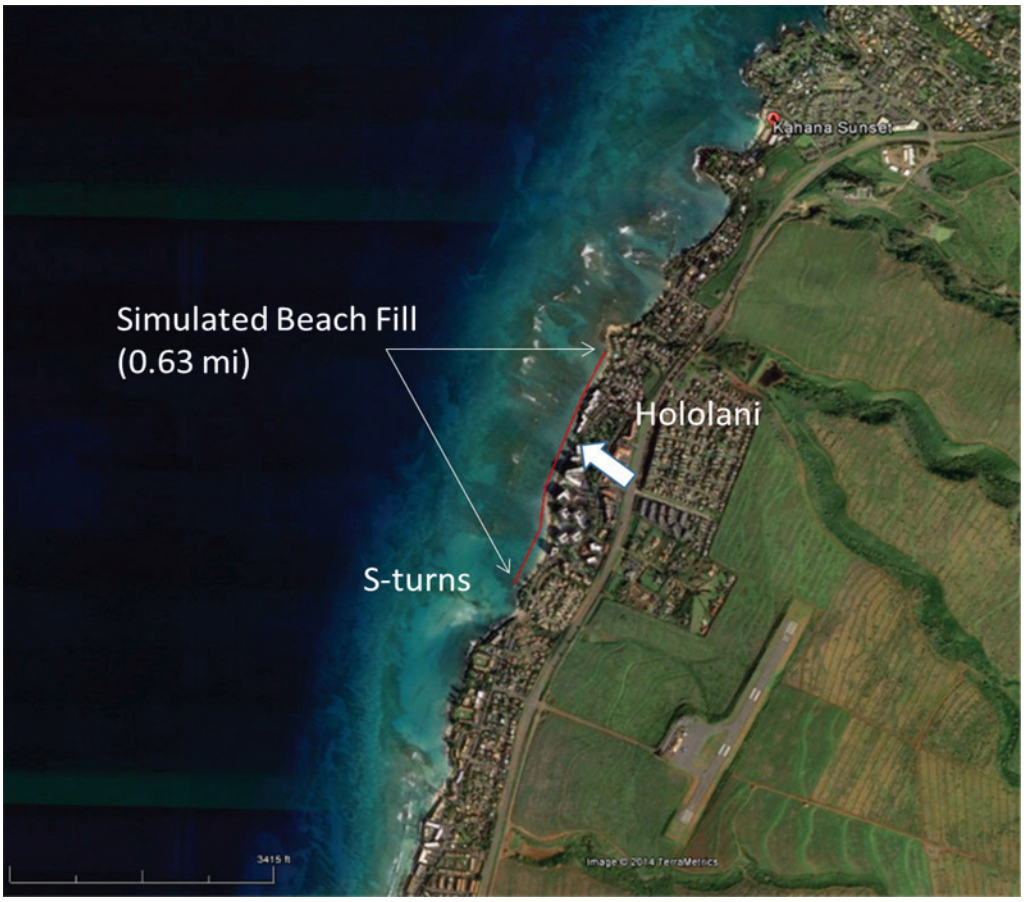

Figure 3. Particle Tracking Model (PTM) simulated beach fill area, Kahana Bay, Maui.

PTM Results for Kahana Bay. Results of the PTM run for the 2003 south swell condition (Figures 4 and 5) indicate that early in the simulation during a period of smaller waves from the south, the nearshore current velocities were small and consistently directed to the north of the initial placement site. Without stabilizing structures the material moved northerly along the nearshore, beyond Kahana Stream and the small headland that separates the Kahana Sunset littoral cell (Figure 4). For the first 3 days of the 9-day simulation, the particles remained within the extents shown in Figure 4. By day 5 of the simulation, the particles moved farther offshore within relic stream channels and to some degree onto the reef (Figure 5). Real-time observations by members of the Hawaii RSM Project Delivery Team (PDT) verified the general sediment transport pathways illuminated by the PTM results shown in Figure 5. These pathways should be investigated for their potential as sustainable offshore borrow areas for beach nourishment.

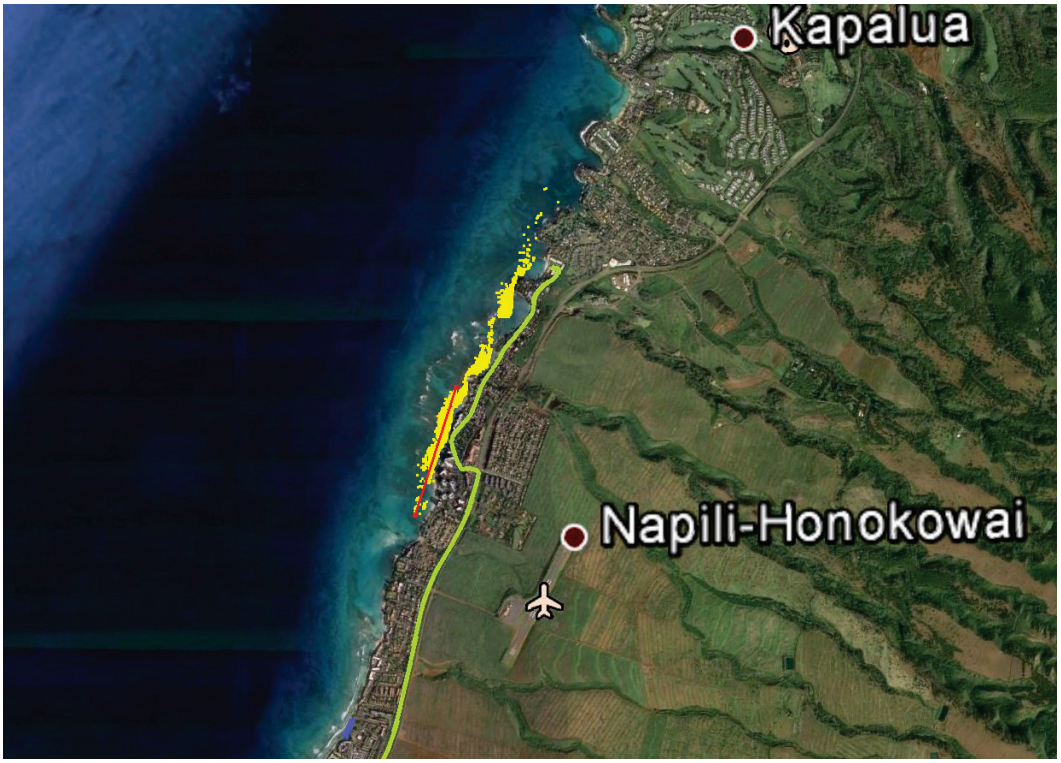

Figure 4. Particle Tracking Model (PTM) 1 day after release of particles, Kahana Bay, Maui.

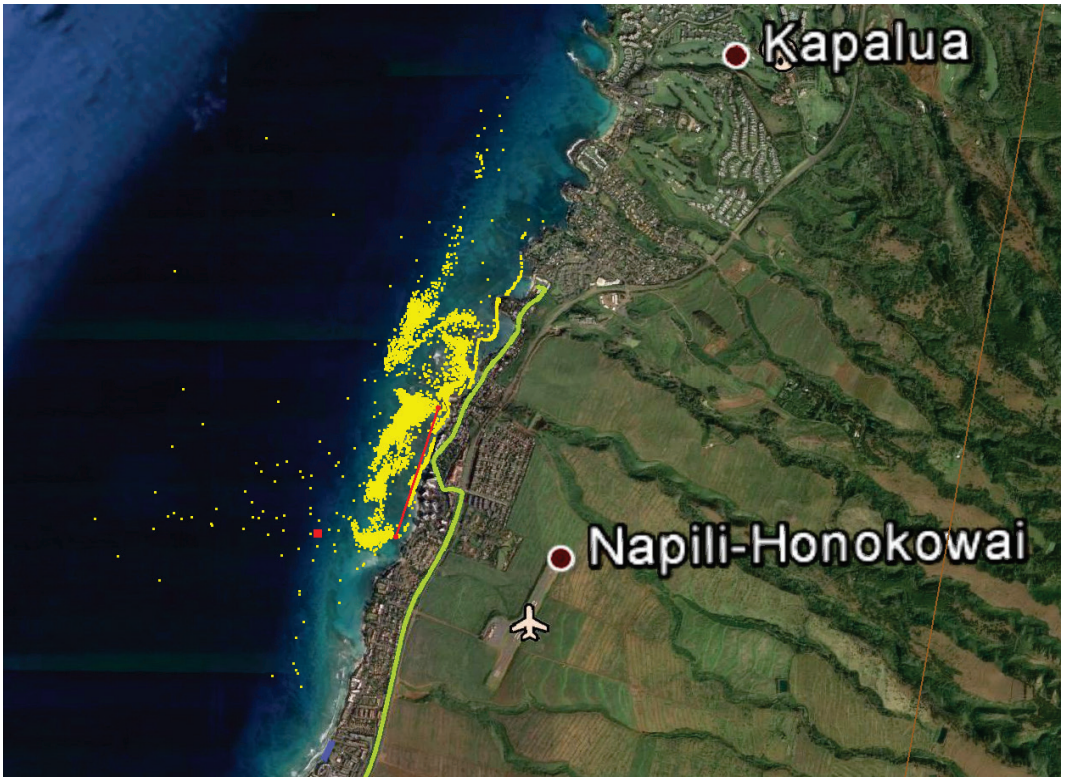

Figure 5. Particle Tracking Model (PTM) 5 days after release of particles, Kahana Bay, Maui.

The results of the PTM run for the 2003 northwest swell condition indicate that the particles were much less stable than for the south swell run. This was due to the larger wave heights associated with the northwest swell. After 1 day, the particles moved in similar fashion to the south swell run after 5 days. Some particles were even transported as far north as Kapalua Point after 1 day. Towards the end of the run (day 11), the majority of the particles had moved away from the placement area as far south as South Kaanapali. This indicates that the PTM is based on limiting assumptions (e.g., no bed load) that preclude its use as a true indicator of volume change in high energy environments.

Note that the PTM simulates suspended transport of material specified as input to the water column. It does not represent bed load transport. Therefore, the resulting transport pathways inferred by the model must be interpreted with caution. It was noted in the Kahana Bay PTM simulations that the particles were transported rapidly from their original placement location. This trend in model results does not suggest that beach fill will not be stable if placed in the area of interest. It is important to consider the pathways that the particles followed relative to regional coastal processes.

CONCLUSIONS: The West Maui Region extends from Hanakaoo to the south through Honolua Bay to the north (Figure 2). Critically eroding beaches in the West Maui Region have been identified by the County of Maui Planning Department and other stakeholders. This CHETN identifies various RSM projects or opportunities that could potentially be implemented through acquisition of appropriate federal authorizations; by other Federal, state, and/or county agencies; by partnerships; or by the private sector. A workshop was held on 17 August 2014 in Kihei to solicit stakeholder input on Potential RSM Projects (PRSMP) for the region. Engineering and environmental considerations associated with implementation of PRSMPs were discussed and evaluated.

The County of Maui identified Kahana Bay as its first PRSMP priority. Previous numerical modeling capabilities were leveraged to investigate beach nourishment performance in the Kahana Bay littoral cell through visualization of sediment transport pathways via the PTM. PTM results indicated that material placed on the beach would migrate offshore along relic stream channel alignments under the forcing of south swell waves. Longshore transport to approximately 0.5 miles north of the placement area was predicted over a 9-day simulation. The particle transport results for PTM simulation of a large northwest swell were similar to the south swell run in the cross-shore direction but extended much farther longshore in both north and south directions.

Based on the West Maui RSM workshop findings, the following engineering and environmental considerations should be incorporated into the development of an RSM project for Kahana Bay.

Kahana Bay Engineering Considerations.

1. Quantify the volume of suitable offshore sand available and the cost associated with dredging and placing it on the beach.
2. Determine the nominal interval for beach renourishment.
3. Identify the impacts of beach nourishment (both economic and environmental).
4. Investigate the need for terminal structures.

5. Determine the potential for hotels to share in the cost of beach nourishment projects.
6. Quantify the engineering benefits of combining different shore protection alternatives.
7. Review the Napili Bay/Kapalua beach nourishment plan.

Kahana Bay Environmental Considerations.

1. Determine the consequences of introducing sediment into the littoral environment.
2. Ensure that beach fill material is compatible with the native beach sand.
3. Investigate the potential impacts of utilizing offshore sand resources for beach nourishment.
4. Conduct ecological assessment of beach fill to investigate sustainability and identify long-term impact.

ADDITIONAL INFORMATION: This Coastal and Hydraulics Engineering Technical Note (CHETN) was prepared as part of the USACE Regional Sediment Management (RSM) Program and was written by Thomas D. Smith, USACE, Honolulu District, Honolulu, HI, with input from the Hawaii RSM PDT. David A. Lau is the USACE Pacific Ocean Division (POD) RSM Point of Contact (POC). Additional information pertaining to the Hawaii RSM investigations can be found at *http://gis.poh.usace.army.mil/rsm/index.htm*, and pertaining to the USACE RSM Program can be found at *http://rsm.usace.army.mil*.Questions regarding this CHETN or the USACE RSM Program may be addressed to the following:

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